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GENERAL SCIENCE IN THE UNIVERSITY HIGH SCHOOL, EUGENE, OREGON

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It has become more and more apparent with the passing of time that the future for general science in the school curriculum is much more a question of developing a proper pedagogical method of instruction than a matter of what shall form the exact content of such a course. Local situations should play a large part in the latter question, and for the remainder of the material we should look to the immediate environment of the child. There is open to science teachers a splendid opportunity to utilize the heritage of past experience in the teaching of this new subject which has not as yet been formalized by traditions. If general science can call forth a new and more suitable method of presentation, not only is its own future secured, but, what is more important, a service of the greatest value to the teaching of the sciences in general will result.

The past has given us at least two principles which have been quite generally accepted. These are, first, the laboratory approach to science study and, second, the inductive method. Even these, partly for administrative reasons and partly because of failure to realize their values, have been the ideal rather than the actual procedure. Our high schools today are still giving textbook courses

in the sciences with fatal results, as is shown by the steady decline of the special sciences. The laboratory work which accompanies our science courses appears to be quite incidental and subordinate to the use of the textbook.

Looking toward the future we cannot be so certain what will be the guiding principles a few years hence. Perhaps of all the movements in the field of science instruction that toward a wider utilization of the problem method seems to offer the most promise of desirable results. Nevertheless the problem method is far from being developed to a point where most teachers can make much use of this idea. Again it is very likely that to attempt to reduce all teaching to the problem basis would not be for the best. It will require time and careful thought to make the most of this tool, and for the present at least the problem must remain as a standard by which we may occasionally check our results and toward which we may seek to approximate.

To apply these principles to the question of the future of general science, it seems to the writer that the justification or elimination of this new subject depends upon how safely we avoid the error of falling back into the textbook type of course and how skilfully we can make use of the newer types of teaching that are being developed. The general-science course which is an assemblage of chapters from textbooks of the special science is bound to be a hodgepodge, is sure to be superficial and devoid of real vitality, and is destined to prove a failure. It is squarely up to us to develop an adequate technique of presentation in such a beginning course if it is to fill a vital need. A moment's thought will show the futility of hoping to teach much material that has not been taught, time and time again, in the various special sciences.

It is hoped that the course in general science as now given in the University High School, Eugene, Oregon, has in some measure incorporated the best that the past has given as well as some of the present tendencies in general-science teaching. In the main our plan seeks to do three things, as follows:

1. To make the work strictly experimental by using the laboratory approach to all topics. This is then supplemented by a study of textbook materials.

2. To use the inductive method as widely as possible.
3. To incorporate some of the desirable features of the problem method of instruction.

In order to carry out these principles the year's work is organized in fifteen units, which for the lack of a better name are termed problems. It is admitted that these units fall far short of the ideal problem, yet it is hoped that the units approach the ideal somewhat closer than do most units of instruction. Each problem involves the performance of from three to eight or more simple experiments, each of which contributes something to the solution of the question which forms the statement of the problem. Experience has shown that this arrangement of giving all the laboratory work on a topic over a number of consecutive days gives an emphasis and continuity that cannot be had otherwise. The experiment records are all carefully written up in the laboratory, collected, and graded. It has been found that a much higher standard of work can be obtained by grading upon the following basis: Paper on Time, 15 per cent; Neatness, 25 per cent; Accuracy, 30 per cent; Completeness of Statement, 30 per cent.

The work in the laboratory is then followed by a number of days of assigned study or reading. Two texts are used, the selections for this year being Caldwell and Eikenberry, *General Science*, and Pease, *A First Course in General Science*. Supplementary materials are found in various texts of this nature, government publications, and current magazine literature. The following books have been found very helpful: Jewett, *The Next Generation*, which forms the basis of the last four weeks of the course; Olsen, *Pure Foods*; and Stevens, Burkett, and Hill, *Agriculture for Beginners*, for certain problems in agriculture. Home projects, such as the making of a garden, and field trips supplement the work at school. The fifteen units composing the year's work are selected so as to involve the learning of usable knowledge which is full of meaning to the adolescent pupil. The attempt is made to anticipate the questions which are most likely to arise out of the immediate environment of the child. The titles of the problems and the experiments involved in each, together with the time allotted, follow.

FIRST SEMESTER

PROBLEM I. WHAT IS THE EARTH'S PLACE IN THE UNIVERSE?

- Experiment 1. What is the relation of the earth to the other planets?
 Experiment 2. What is the relation of the earth to the sun and moon?
 Experiment 3. What is the cause of the changes of the moon?
 Experiment 4. What causes the change from summer to winter?
 Experiment 5. How is temperature measured? The thermometer.
 Experiment 6. How is heat transferred from one place to another?
 Readings: Caldwell and Eikenberry, 11-20; Pease, 13-45, 71-80.

Time: Three weeks.

PROBLEM II. HOW DOES MAN TAKE ADVANTAGE OF THE AIR?

- Experiment 1. What are the main facts (properties) about air?
 a) Does air occupy space (i.e., have volume)?
 b) Can air be made to change its volume (i.e., can it undergo expansion and contraction)?
 c) Does air completely fill the space that it appears to occupy (diffusion)?
 d) Does air have weight (pressure)?

Experiment 2. How can we measure the pressure of the air? The barometer.

Experiment 3. What fact that we have learned about air is made use of in the siphon?

Experiment 4. What fact about air is concerned in the lift and force pump?

Readings: Caldwell and Eikenberry, 1-12, 49-54, 118-22; Pease, 93-106.

Time: Two weeks.

PROBLEM III. WHAT ARE SOME OF THE LAWS GOVERNING THE WEATHER?

- Experiment 1. What is the relation of high and low pressure areas to winds?
 Experiment 2. What effect does the rotation of the earth have upon the direction of the winds?
 Experiment 3. What are the principal wind zones of the earth?
 Experiment 4. Why does dew form and how can we find the dew point?
 Experiment 5. What is meant by relative humidity and how can it be determined?

Readings: Caldwell and Eikenberry, 21-48; Pease, 107-118; *The Mentor*, serial number 110, "The Weather," by C. T. Talman.

Time: Two weeks.

PROBLEM IV. HOW DO BODIES OF WATER AFFECT THE CLIMATE?

- Experiment 1. Do all substances heat equally?
 Experiment 2. How do the Great Lakes affect the climate of the surrounding country?
 Experiment 3. What is the effect of the Pacific Ocean on the climate of Oregon?

Readings: Caldwell and Eikenberry, 136-53; Pease, 116-19.

Time: One week.

PROBLEM V. ARE THERE LIVING FORMS IN THE AIR AND WATER?

- Experiment 1. What are bacteria and how do they multiply?
 Experiment 2. What is the importance of yeasts and molds?

Experiment 3. How are bacteria used in some common industries?

Experiment 4. How are bacteria related to disease?

Experiment 5. How does the septic tank do its work?

Readings: Caldwell and Eikenberry, 79-101, 154-64; *Farmers' Bulletins*,

Nos. 490, 473, 449, 155.

Time: Two weeks.

PROBLEM VI. CAN MATTER BE CHANGED FROM ONE FORM INTO ANOTHER?

Experiment 1. What are physical changes?

Experiment 2. What are chemical changes?

Experiment 3. (Optional) What are mixtures?

Experiment 4. Is the burning of a candle a physical or a chemical change?

Experiment 5. Is the action of the electric current upon water a physical or a chemical change?

Experiment 6. What is the nature of the two gases formed by the action of the electric current on water?

Readings: Caldwell and Eikenberry, 55-66; Pease, 46-56, 82-83, 138-45, 147-66.

Time: Two weeks.

PROBLEM VII. WHAT PHYSICAL CHANGES CAN WATER UNDERGO?

Experiment 1. What are the three physical states of matter?

Experiment 2. What is distillation?

Experiment 3. What are the conditions governing evaporation?

Experiment 4. Do plants evaporate water from their leaves?

Experiment 5. Does evaporation affect the temperature?

Experiment 6. What are some common applications of the laws of evaporation?

a) The wet-bulb thermometer (Problem III).

b) Manufacture of artificial ice.

Readings: Caldwell and Eikenberry, 103-117; Pease, 67-70.

Time: Two weeks.

PROBLEM VIII. WHAT USES CAN BE MADE OF THE FACT THAT LIQUIDS EXERT PRESSURE?

Experiment 1. What is meant by buoyancy?

Experiment 2. How can we make use of buoyancy in finding the density of an object?

Experiment 3. How else can the density of a solid be found?

Experiment 4. How can the density of a liquid be found?

Experiment 5. What is the principle of the hydraulic press?

Readings: Caldwell and Eikenberry, 122-35; Pease, 63-67, 81-92.

Time: Three weeks.

SECOND SEMESTER

PROBLEM IX. CAN ENERGY BE CHANGED FROM ONE FORM INTO ANOTHER?

Experiment 1. What is the relation of friction to heat?

Experiment 2. What happens when a rubber rod is rubbed?

Experiment 3. Are there energy changes when a salt dissolves in water?

- Experiment 4. What is the nature of magnetism?
 Experiment 5. What is the principle of the steam engine?
 Experiment 6. (Optional) What is the principle of the gas engine?
 Readings: Caldwell and Eikenberry, 180-89; Pease, 79-80, 120-37.
 Time: Two weeks.

PROBLEM X. WHAT ARE THE USES OF THE LEVER?

- Experiment 1. What are the three classes of levers, and what are the advantages of each?
 Experiment 2. What are the uses and advantages of the pulley?
 Experiment 3. How do the muscles of our bodies act as levers?
 Experiment 4. What is the relation of the lever and pulley to work?
 Readings: Caldwell and Eikenberry, 165-69, 170-79; Pease, 56-63.
 Time: Two weeks.

PROBLEM XI. WHAT IS THE NATURE OF THE SOIL?

- Experiment 1. Does the soil contain water?
 Experiment 2. Is there organic matter (humus) in the soil?
 Experiment 3. Are there soluble materials in the soil?
 Experiment 4. Are there living forms in the soil?
 Experiment 5. What makes up the body of the soil?
 Summary: The percentage composition of the soil as found in the foregoing analysis.
 Readings: Stevens, Burkett, and Hill, 1-26; Caldwell and Eikenberry, 191-226; Pease, 90-92, 167-253.
 Time: Three weeks.

NOTE: This problem and the one following are carried out in connection with the planning, planting, and care of a garden as a home project.

PROBLEM XII. HOW DOES THE PLANT GET IN CONTACT WITH ITS SURROUNDINGS?

- Experiment 1. How do the roots get in contact with the soil?
 a) What are root hairs?
 b) What is the nature of osmosis?
 c) What is the importance of capillarity?
 d) What is the path of ascent of materials in plant stems?
 Experiment 2. How does the plant get in contact with the air?
 a) What is the structure of the leaf?
 b) What is the breathing apparatus of plants?
 c) Do leaves take up and throw off gases?
 Readings: Stevens, Burkett, and Hill, 27-35; Caldwell and Eikenberry, 67-74; 234-40; Pease, 265-69.
 Time: One week.

PROBLEM XIII. HOW DOES THE WORLD GET ITS FOOD SUPPLY?

- Experiment 1. How is starch formed in the plant?
 Experiment 2. What are the properties of starch?
 Experiment 3. What are the waste products in food making?
 Experiment 4. What part does diastase play in plants?

Experiment 5. What are the tests for the different foods?

Experiment 6. (Optional) What are some simple ways of detecting adulterations in foods?

Readings: Olsen, 64-68, 74-76, 97-99, 122-40; Pease, 269-73; Caldwell and Eikenberry, 74-78, 241-52, 265-67.

Time: Three weeks.

PROBLEM XIV. WHAT ARE THE CHARACTERISTICS OF LIVING MATTER?

Experiment 1. What is the nature of respiration?

Experiment 2. What is the nature of nutrition?

Experiment 3. What is growth?

Experiment 4. What is the purpose of excretion?

Experiment 5. What responses do plants and animals make to outside influences?

Experiment 6. What is the significance of reproduction?

Readings: Caldwell and Eikenberry, 252-69; Pease, 54-55, 272-75, 282-97.

Time: Two weeks.

PROBLEM XV. WHAT IS THE SIGNIFICANCE OF REPRODUCTION AND INHERITANCE?

Experiment 1. How does *Pleurococcus* multiply? The yeast plant?

Experiment 2. What is the life-history of the frog?

Experiment 3. How do the flowering plants reproduce?

Experiment 4. What are the stages in the germination of seeds?

Experiment 5. What is meant by variation?

Experiment 6. What do we know of the laws of inheritance?

Readings: Jewett, 1-80, 100-204; Pease, 298-302; Caldwell and Eikenberry, 270-302.

Time: Four weeks.

In order to present the type of class exercises accompanying the problems as worked out in the laboratory, the full outline for class discussion of one of the problems, viz., the last one above, is given here.

PROBLEM XV

A. Simple types of reproduction among the lowest animals and plants (vegetative reproduction)

1. Budding, e.g., the yeast plant

2. Splitting, e.g., the bacteria

B. Reproduction by eggs and sperms (sexual reproduction)

1. Conjugation, e.g., the pond scum

2. Fertilization, e.g., the frog

3. Flowering plants

a) Pollination

b) Fertilization

c) Development of the embryo

d) Germination of the seed

4. Mammals

C. Meaning of reproduction

Law: Every animal or plant seeks to reproduce its own kind

D. The "five-linked chain" (Jewett)

1. Overproduction
 - a) The balance of nature
2. Struggle for existence
3. Variation
 - a) Hybridization
4. Natural selection or the survival of the fittest
 - a) Artificial selection
 - (1) Work of Luther Burbank
5. Heredity
 - a) Life-story of Gregor Johann Mendel
 - b) The laws worked out by Mendel, as illustrated by
 - (1) Sweet peas
 - (2) Andalusian chickens
 - (3) Feeble-mindedness
 - c) The future of the human race
 - (1) Environment versus heredity

The references for study given with each problem outline are by no means all of the reading required in some cases, additional lists being issued from time to time. Home experiments are sometimes required and others suggested. Construction and investigation projects are outlined in many cases. Most of the study and reading is done at school under the supervision of the teacher. The class exercises are more of the nature of discussions than recitations of the usual sort. About one day each month is devoted to discussion of any questions which the pupils may bring in, whether arising in the home or at school, the only restrictions being that such topics must have some relation to science in a very broad way.

This course is now given in the Junior third and fourth semesters, which correspond to the eighth grade of the 8-4 plan. The work is constantly in a state of change and is far from being entirely satisfactory. It does, however, in its present form, represent the result of four years' experience of the writer in teaching general science to a large number of pupils.